UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EVALUATION OF NEEM AND PAPAYA LEAVES EXTRACT AS AN ECO-FRIENDLY CORROSION INHIBITOR FOR CARBON STEEL IN 0.5 M HCl MEDIUM

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A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled " Evaluation of Neem and Papaya Leaves Extract as an Eco-Friendly Corrosion Inhibitor for Carbon Steel in 0.5 M HCl Medium " is the result of my own study except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	:	17 January 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours.

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Date : 17 January 2022

DEDICATION

Any hard task involves self-effort as well as the advice of elders, particularly those close to my heart.

My heartfelt gratitude and modest effort go to my wonderful and loving family, especially my mother, father, and younger brother.

Whose love, a tremendous source of inspiration, encouragement, and prayers throughout the day and night enable me to achieve such glory and achievement.

Including all of my great training and respect for my supervisor, Dr. Mohd Fauzi Bin Mamat.

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ABSTRACT

Carbon steel is made up of the fundamental elements of iron and carbon. Carbon steels are often used in different applications, including structural components such as steel frame buildings, automotive tubing, pipelines, and tanks. Corrosion is characterized as a indirectional electrochemical interaction between a material and it's environment, which can result in the material corroding. Corrosion inhibitor is one of the method to corrosion protection. A corrosion inhibitor is a chemical compound that reduces the rate of metal corrosion when exposed to the environment. Green inhibitors are biodegradable corrosion inhibitors that are inexpensive and environmentally safe without heavy metals, chemicals, some hazardous substances and are capable of effectively retarding corrosion. This study aim is to evaluate neem and papaya leaves extract as an eco-friendly corrosion inhibitor for carbon steel in a 0.5 M HCl medium. The objectives of this study are to investigate the influence of the immersion period on the inhibition efficiency of the green inhibitors, to evaluate the inhibition efficiency of neem and papaya leaves as plant-based green inhibitors for low carbon steel in a 0.5 M HCl acidic medium, and also to compare the performances of the neem and papaya leaves in preventing corrosion in low carbon steel. In this research study, a mechanical testing had been done, which is to evaluate the analysis of the hardness and microstructure of the low carbon steel. The sample has been divided into three samples, which are HCl added with neem leaves extract, HCl added with papaya leaves extract, and HCl only. Each sample contains six low carbon steel specimens and has been observed for 7, 14, 21, 28 and 35 days. The specimen had been taken out according to the days that were required, and the result will be a visual inspection and calculation of weight loss measurement, corrosion rate and inhibitor efficiency. The mechanism of adsorption of inhibitors on the surface of low carbon steel materials had been studied by using Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray (EDX). The SEM study of the surface on low carbon steel was done to prove the effectiveness of the eco-friendly inhibitor as a corrosion preventative. The weight loss result such as on days 35 the total weight loss of 0.5 M HCl is 1.401 gram, papaya leaves solution is 0.846 gram and neem leaves solution is 0.692 gram has demonstrated that the involvement of an eco-friendly inhibitor, which is papaya and neem leaves, had reduce carbon steel's corrosion rate with 0.0114 mm/year and 0.0093 mm/year respectively. SEM and EDX analysis proved that the specimen surface in 0.5 M HCl solution got a lot of pitting, which is corroded compared to specimen surfaces in the papaya and neem leaf medium. In other words, the green inhibitor has been used in close systems of the oil and gas industries, such as boilers, pipelines, pressure tanks, and pressure vessels. The inhibitor effectiveness of neem leaves is the best green inhibitor considering the maximum value of corrosion rate and the highest value of inhibitor efficiency.

ABSTRAK

Keluli karbon terdiri daripada unsur asas besi dan karbon. Keluli karbon sering digunakan dalam aplikasi yang berbeza, termasuk komponen struktur seperti bangunan kerangka keluli, tiub automotif, saluran paip, dan tangki. Hakisan dicirikan sebagai interaksi elektrokimia secara tidak langsung antara bahan dan persekitarannya, yang boleh mengakibatkan pengaratan bahan. Perencat kakisan adalah salah satu kaedah untuk melindungi kakisan. Perencat kakisan adalah sebatian kimia yang mengurangkan kadar kakisan logam apabila terdedah kepada persekitaran. Perencat kakisan hijau adalah penghambat kakisan yang boleh terbiodegradasi yang murah dan selamat dari persekitaran tanpa logam berat, bahan kimia, beberapa bahan berbahaya dan mampu melambatkan kakisan dengan berkesan. Tujuan penyelidikan ini adalah untuk menilai ekstrak daun neem dan betik sebagai penghambat kakisan mesra alam untuk keluli karbon dalam medium 0.5 M HCl. Objektif kajian ini adalah untuk mengkaji pengaruh tempoh rendaman terhadap kecekapan penghambatan perencat kakisan hijau, untuk menilai kecekapan penghambatan daun neem dan betik sebagai perencat hijau berasaskan tumbuhan untuk keluli karbon rendah dalam medium berasid 0.5 M HCl, dan juga untuk membandingkan prestasi anatara daun neem dan betik dalam mencegah kakisan pada keluli rendah karbon. Dalam kajian penyelidikan ini, pengujian mekanikal telah dilakukan, iaitu untuk menganalisis kekerasan dan struktur mikro keluli rendah karbon. Sampel telah dibahagikan kepada tiga sampel, yang ditambahkan HCl dengan ekstrak daun neem, HCl ditambahkan dengan ekstrak daun betik, dan HCl sahaja. Setiap sampel mengandungi enam spesimen keluli rendah karbon dan telah diperhatikan selama 7, 14, 21, 28 dan 35 hari. Spesimen telah dikeluarkan sesuai dengan hari-hari yang diperlukan, dan hasilnya akan menjadi pemeriksaan visual dan perkiraan penurunan berat specimen, kadar kecepatan penghakisan dan efisiensi penghambat. Mekanisme penyerapan perencat pada permukaan bahan keluli rendah karbon telah dikaji dengan menggunakan Mikroskop elektron pengimbas (SEM) dan Sinar-X penyebaran tenaga (EDX). Kajian SEM permukaan pada keluli rendah karbon dilakukan untuk membuktikan keberkesanan perencat mesra alam sebagai pencegahan kakisan. Hasil penurunan berat spesimen iaitu 1.401 gram dalam larutan 0.5 M HCl is 0.846 gram dalam larutan daun betik, dan 0.692 gram dalam larutan daun neem telah menunjukkan bahawa penglibatan perencat mesra alam, yang merupakan daun betik dan daun neem, ia mengurangkan kadar kakisan keluli karbon iaitu 0.0114 mm/tahun and 0.0093 mm/tahun. Analisis SEM dan EDX membuktikan bahawa permukaan spesimen dalam larutan 0.5 M HCl mendapat banyak hakisan berkarat dibandingkan dengan permukaan spesimen di media daun neem dan betik. Dengan kata lain, perencat kakisan hijau telah digunakan dalam sistem terutama di industri minyak dan gas, seperti dandang, saluran paip, tangki tekanan, dan kapal tekanan. Keberkesanan penghambat daun neem sebagai perencat hijau adalah paling terbaik memandangkan nilai maksimum kadar kakisan dan nilai kecekapan perencat tertinggi.

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LIST OF SYMBOLS AND ABBREVIATIONS

SEM	-	Scanning Electron Microscopy
EDX	-	Energy Dispersive X-Ray
W_o	-	Weight absence of inhibitor
W_i	-	Weight presence of inhibitor
I.E(%)	-	Percent inhibitor efficiency
mm/yr	-	Milimeter per year
HCl	-	Hydrochloric acid
FTIR	-	Fourier transform infrared spectroscopy
g	-	Gram
L	-	Litre
mL	-	mililitre
gL	-	gram per litre
M	-	Mol/L

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Carbon steels typically have a carbon content of 1.5 percent or less, as well as trace amounts of Manganese (Mn), Silicon (Si), Phosphorus (P), and Sulfur (S). Classification has been segmented further based on carbon percent. The categorization is based on the proportion of carbon, with low carbon steels (0.25% C), medium carbon steels (0.25 – 0.70% C), and excessive carbon steels (0.70 – 1.05% C) being the maximum commonplace. On top of that, the carbon content may be modified to produce various mechanical properties like strength, ductility, hardness, and so on. Carbon steels are often utilized in an expansion of applications, along with structural components such as steel frame structures, automotive tubing, device parts, and cookware (Dwivedi, Lepková and Becker, 2017). Corrosion is one of the problems that carbon steel faces as a result of inadequate protection. In general, the factors affecting the corrosion rate of plain carbon steel are either material-dependent or environment-dependent, or a mixture of both (Uzorh, 2013).

Corrosion is characterized as ‘a unidirectional electrochemical interaction between a substance such as metal, ceramic, or polymer and its environment can result in the material being eaten or a component of the environment being dissolved into the substance’ (Popoola, Olorunniwo and Ige, 2014). In addition, corrosion is the wear and tear caused by chemical reactions, most notably oxidation. Accordingly, this problem arises once a gas or liquid with chemicals contacts associate exposed surface, typically a metal, assisted by high temperatures, acids, and salts. Corrosion additives together with rust and patina generally

stay at the surface and characteristic as barrier. For that reason, removing these deposits exposes the soil once more, resulting in corrosion. Certain materials are evidently proof against corrosion, at the same time as others can be protected with the aid of coating, painting, galvanizing, or anodizing. Whilst most people or all of the atoms on a metal surface oxidise, the entire surface is prompted. Moreover, most metals oxidise quickly, resulting in electron losses to oxygen and different compounds within the air (Hussain *et al.*, 2020).

Corrosion inhibitors are made up of both chemical compounds. A corrosion inhibitor, from either perspective is a chemical compound when released into the environment, can slow the rate of metal corrosion. Other corrosion-fighting ways on the market, as well as cathodic protection, organic coatings, and therefore the use of high-quality corrosion-resistant alloys, film-forming inhibitors still the last word means of interference for mild steel in sulphuruous conditions (Tamalmani and Husin, 2020). Consequently, there are several methods that have been developed to use corrosion prevention methods and one of which is the advantage of green corrosion inhibitors. The benefit of green inhibitors for prevent of metals and alloys connected with extreme environments has recently become a well-liked and growing technology. Plant extracts associated with the organic family are shown to be necessary as an environmentally friendly, easily accessible, and long-lasting resource for a variety of applications. They are enriched with chemicals with great inhibitory efficiency and are hence known as "Green Inhibitors." Green corrosion inhibitors are biodegradable corrosion inhibitors that are devoid of heavy metals, chemicals, and some hazardous substances (Sharma *et al.*, 2009). These green inhibitors are organic compounds that resist corrosion by surface assimilation on the metal's surface. Moreover, in conjunction with their food content, minerals, similarly to synthetic resin compounds, fruit-based corrosion inhibitors are one of all the natural parts used. Nevertheless, corrosion inhibitors respond to explicit factors like concentration, rate of dispersion, velocity, temperature, film

persistence, pH, flow regime, and fluid structure, and, additionally, the presence of instabilities capable of distressing the flow so as to cut back on corrosion (Tamalmani and Husin, 2020).

In this study, low carbon steel became decided on as the substrate and simulate in an acidic environment, namely a 0.5 M HCl solution. Furthermore, two different types of green inhibitors, which are neem and papaya leaf extract, were dissolved completely in the 0.5 M HCl medium. It is preferable for the neem and papaya leaf extracts to establish a homogenous protective guard on the low carbon steel surface, separating the corrosive media from the reactive areas towards the low carbon steel. In particular, a range of research methodologies were used to acquire perception into the anti-corrosive mechanism of the barrier layer formed on the low carbon surface by neem and papaya leaves, such as mechanical testing, visual inspection, weight loss measurement, corrosion rate, and inhibitor efficiency.

1.2 Problem Statement

The corrosion process is amongst the most damaging processes, producing massive economic damage in the automotive, marine, oil and gas, and aerospace sectors in particular. Every attempt has been made to minimize large losses caused by metal corrosion of alternative materials and material selection. Accordingly, implementing inhibitors for corrosion safety in marine and acidic environments as well as good protection for metals. Otherwise, the most common use is inorganic inhibitors. Chromates, nitrates, molybdates, and tungstate are just a few examples. On the whole, the utilization of inhibitors could be a well-known strategy once metal corrosion has to be prevented and controlled. The compounds are expensive, poisonous and harmful, resulting in adverse effects on humans and the environment. Regarding these issues, green inhibitors were selected because it is

least expensive, biodegradable, ecologically acceptable, and renewable. In the form of the circular economy, their valorization widens potential uses in manufacturing fields other than "waste to energy." Therefore, it is necessary to design and produce green inhibitors from trees, leaves, and other natural materials that are both inexpensive and environmentally safe and capable of effectively retarding corrosion.

1.3 Objective of Study

The primary objective of this study is to evaluate neem and papaya leaf extract as an environmentally friendly corrosion inhibitor for low carbon steel in a 0.5 M HCl medium. Specifically, the following are the study's objectives:

i. To investigate the influence of the immersion period on the inhibition efficiency of the green inhibitors.

ii. To evaluate the inhibition efficiency of neem and papaya leaves as plant-based green inhibitors of low carbon steel in an acidic medium.

iii. To compare the performance of the selected green inhibitor in preventing corrosion on low carbon steel in an acidic medium.

1.4 Scope of Study

The scope of this research is as follows:

i. To observe the best method of green inhibitor to perform as anti corrosion overall performance of inhibitor on a low carbon steel substrate for apply in the oil and gas sectors.

ii. Selection of suitable plants which are neem and papaya leaves to be extracted as green organic inhibitors.

iii. Preparation of plant-based green organic inhibitors for extraction.

iv. Using EDM wire cutting machines to cut the substrate material to the diameter of a 25 mm cylinder and a thickness of 4.5 mm.

v. Use a hardness test and an optical microscope to perform mechanical testing on the substrate.

vi. Conduct a corrosion test on the base metallic that was protected through the neem and papaya leaves corrosion inhibitor.

vii. To study corrosion behaviour via an immersion test in 0.5 M HCl.

viii. Divide the sample into three groups, each of which have six samples immersed within 0.5 M HCl and another 12 samples have been immersed in 0.5 M HCl with a different inhibitor for the immersion test.

ix. All samples have been immersed in the 0.5 M HCl medium for a period of 7, 14, 21, 28, and 35 days.

x. Utilize a Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray (EDX) to study the corrosion behavior on the substrate after a test.

1.5 Significant of Study

As an outcome of the study, it offers information on the study's significance. This further explains the significance of the study and it is potential benefits. The aim of this study is to evaluate neem and papaya leaves extract as an environmentally friendly corrosion inhibitor for carbon steel in a 0.5 M HCl medium. Furthermore, this studies had been conducted using specific methods and equipment for the treatment of substrates corrosion as an important eco-friendly corrosion. Therefore, the usable material that neem and papaya leaves extract represents will be analyzed through the process of using the specific machine

and apparatus to run the test inhibition. With added chemicals such as green inhibitors so the goal is to assist industrial oil and gas companies in mitigating corrosion of closed systems such as pipelines, pressure vessels, and tanks. In addition, the green inhibitor that would used is also non-toxic, safe, cheap and biodegradable.

1.6 Organization of Study

This study is divided into five chapters and the contents of which are summarized below, based on the objectives previously presented and the approach previously proposed:

i. Chapter 1. Introduction. This chapter represent the background, objectives, scope, significance and organization of study.

ii. Chapter 2. Literature review. This chapter begins with an introduction to carbon steel and the various types of carbon steel. Later, an overview of corrosion and the subtopic which is a form of corrosion and corrosion behaviour on carbon steel. This chapter also covers corrosion methods, as well as corrosion inhibitors and types of corrosion inhibitors. Moreover, a brief discussion of the green inhibitor. Equally importantly, the summary of the literature review is present.

iii. Chapter 3. Research methodology. This chapter express the methods used to estimate the corrosion inhibitor formula, which offers with a procedure used in this analysis and was then carried out. It also extensively defined and described the study approach. As a consequence, Chapter 3 describes the approach to PSM 1 and PSM 2.